It is claimed:

1. An apparatus, comprising:
a resonator adapted to provide a first signal having a resonant frequency;
an amplifier coupled to the resonator; and
a frequency controller coupled to the resonator, the frequency controller adapted to select a resonant frequency having a first frequency of a plurality of frequencies.

2. The apparatus of claim 1, further comprising:
a frequency divider coupled to the resonator, the frequency divider adapted to divide the first signal having the first frequency into a plurality of second signals having a corresponding plurality of frequencies, the plurality of frequencies substantially equal to or lower than the first frequency.

3. The apparatus of claim 1, wherein the frequency divider is further adapted to divide the first frequency by a rational number.

4. The apparatus of claim 2, wherein the first signal is a differential signal or a single-ended signal.

5. The apparatus of claim 2, wherein the first signal is a differential signal and the frequency divider is further adapted to convert the differential signal to a single-ended signal.

6. The apparatus of claim 2, wherein the first signal is a substantially sinusoidal signal and the frequency divider is further adapted to convert the substantially sinusoidal signal to a substantially square wave signal.

7. The apparatus of claim 2, wherein the frequency divider further comprises a plurality of flip-flops or counters coupled successively in series, wherein an output of a selected flip-flop or counter is a frequency of a previous flip-flop or counter divided by two.

8. The apparatus of claim 2, wherein the frequency divider further comprises a plurality of dividers coupled successively in series, wherein an output of a successive divider is a lower frequency than the output of a previous divider.

9. The apparatus of claim 2, wherein the plurality of dividers are differential, single-ended, or differential and single-ended.

10. The apparatus of claim 2, wherein the frequency divider further comprises a square-wave generator, the square-wave generator adapted to convert the first signal into a substantially square-wave signal having a substantially equal high and low duty cycle.

11. The apparatus of claim 2, further comprising:

a frequency selector coupled to the frequency divider, the frequency selector adapted to provide an output signal from the plurality of second signals.

12. The apparatus of claim 11, wherein the frequency selector comprises a multiplexer and a glitch-suppressor.

13. The apparatus of claim 11, further comprising:

a mode selector coupled to the frequency selector, the mode selector adapted to provide a plurality of operating modes, the plurality of operating modes selected from a group comprising a clock mode, a timing and frequency reference mode, a power conservation mode, and a pulse mode.

14. The apparatus of claim 13, further comprising:

a synchronization circuit coupled to the mode selector; and

a controlled oscillator coupled to the synchronization circuit and adapted to provide a third signal;

wherein in the timing and reference mode, the mode selector is further adapted to couple the output signal to the synchronization circuit to control timing and frequency of the third signal.

15. The apparatus of claim 14, wherein the synchronization circuit is a delay-locked loop, a phase-locked loop, or an injection locking circuit.

16. The apparatus of claim 1, wherein the amplifier further comprises a negative transconductance amplifier.

17. The apparatus of claim 16, wherein the frequency controller is further adapted to modify a current through the negative transconductance amplifier in response to temperature.

18. The apparatus of claim 17, wherein the frequency controller further comprises a current source responsive to temperature.

19. The apparatus of claim 18, wherein the current source has one or more configurations selected from a plurality of configurations, the plurality of configurations comprising CTAT, PTAT, and $PTAT^2$ configurations.

20. The apparatus of claim 16, wherein the frequency controller is further adapted to modify a current through the negative transconductance amplifier to select the resonant frequency.

21. The apparatus of claim 16, wherein the frequency controller is further adapted to modify a transconductance of the negative transconductance amplifier to select the resonant frequency.

22. The apparatus of claim 16, wherein the frequency controller is further adapted to modify a current through the negative transconductance amplifier in response to a voltage.

23. The apparatus of claim 1, wherein the frequency controller further comprises a voltage isolator coupled to the resonator and adapted to substantially isolate the resonator from a voltage variation.

24. The apparatus of claim 23, wherein the voltage isolator comprises a current mirror.

25. The apparatus of claim 24, wherein the current mirror has a cascode configuration.

26. The apparatus of claim 1, wherein the frequency controller is further adapted to modify a capacitance of the resonator in response to fabrication process variation, temperature variation, or voltage variation.

27. The apparatus of claim 1, wherein the frequency controller is further adapted to modify an inductance of the resonator in response to fabrication process variation, temperature variation, or voltage variation.

28. The apparatus of claim 1, wherein the frequency controller further comprises:

a coefficient register adapted to store a first plurality of coefficients; and

a first array having a plurality of switchable capacitive modules coupled to the coefficient register and to the resonator, each switchable capacitive module having a fixed capacitance and a variable capacitance, each switchable capacitive module responsive to a corresponding coefficient of the first plurality of coefficients to switch between the fixed capacitance and the variable capacitance and to switch each variable capacitance to a control voltage.

29. The apparatus of claim 28, wherein the plurality of switchable capacitive modules are binary-weighted.

30. The apparatus of claim 28, wherein the frequency controller further comprises:

a second array having a plurality of switchable resistive modules coupled to the coefficient register and further having a capacitive module, the capacitive module and the plurality of switchable resistive modules further coupled to a node to provide the control voltage, each switchable resistive module responsive to a corresponding coefficient of a second plurality of coefficients stored in the coefficient register to switch the switchable resistive module to the control voltage node; and

a temperature-dependent current source coupled through a current mirror to the second array.

31. The apparatus of claim 1, wherein the frequency controller further comprises:

a process variation compensator, the process variation compensator coupled to the resonator and adapted to modify the resonant frequency in response to fabrication process variation.

32. The apparatus of claim 31, wherein the process variation compensator further comprises:

a coefficient register adapted to store a plurality of coefficients; and

an array having a plurality of switchable capacitive modules coupled to the coefficient register and to the resonator, each switchable capacitive module having a first fixed capacitance and a second fixed capacitance, each switchable capacitive module responsive to a corresponding coefficient of the plurality of coefficients to switch between the first fixed capacitance and the second fixed capacitance.

33. The apparatus of claim 32, wherein the plurality of switchable capacitive modules are binary-weighted.

34. The apparatus of claim 31, wherein the process variation compensator further comprises:

a coefficient register adapted to store a plurality of coefficients; and

an array having a plurality of switchable variable capacitive modules coupled to the coefficient register and to the resonator, each switchable variable capacitive module responsive to a corresponding coefficient of the plurality of coefficients to switch between a first voltage and a second voltage.

35. The apparatus of claim 34, wherein the plurality of switchable variable capacitive modules are binary-weighted.

36. The apparatus of claim 31, wherein the process variation compensator further comprises:

a coefficient register adapted to store a plurality of coefficients; and

an array having a plurality of switchable capacitive modules coupled to the coefficient register and to the resonator, each switchable capacitive module having a fixed capacitance and a fuse, each switchable capacitive module responsive to a corresponding coefficient of the plurality of coefficients to open circuit the fuse.

37. The apparatus of claim 1, further comprising:

a frequency calibration module coupled to the frequency controller, the frequency calibration module adapted to modify the resonant frequency in response to a reference signal.

38. The apparatus of claim 37, wherein the frequency calibration module comprises:

a frequency divider coupled to the frequency controller, the frequency divider adapted to convert an output signal derived from the first signal having the first frequency to a lower frequency to provide a divided signal;

a frequency detector coupled to the frequency divider, the frequency detector adapted to compare the reference signal to the divided signal and provide one or more up signals or down signals; and

a pulse counter coupled to the frequency detector, the pulse counter adapted to determine a difference between the one or more up signals or down signals as an indicator of a difference between the output signal and the reference signal.

39. The apparatus of claim 1, wherein the resonator comprises an inductor (L) and a capacitor (C) coupled to form an LC-tank, the LC-tank having a selected configuration of a plurality of LC-tank configurations.

40. The apparatus of claim 1, wherein the resonator is selected from a group comprising: a ceramic resonator, a mechanical resonator, a microelectromechanical resonator, and a film bulk acoustic resonator.

41. The apparatus of claim 1, wherein the resonator is electrically equivalent to an inductor (L) coupled to a capacitor (C).

42. The apparatus of claim 1, wherein the apparatus is a timing and frequency reference.

43. The apparatus of claim 1, wherein the apparatus is a clock generator.

44. The apparatus of claim 1, wherein the frequency controller further comprises:

a temperature compensator coupled to the amplifier;

a voltage isolator coupled to the resonator; and

a process variation compensator coupled to the resonator.

45. The apparatus of claim 1, wherein the apparatus is integrated monolithically with a second circuit to form a single integrated circuit.

46. The apparatus of claim 1, wherein the second circuit is a microprocessor, a digital signal processor, a radio frequency circuit, or a communications circuit.

47. The apparatus of claim 1, further comprising:

a second oscillator providing a second oscillator output signal; and

a mode selector coupled to the frequency controller and to the second oscillator, the mode selector adapted to switch to the second oscillator output signal to provide a power conservation mode.

48. The apparatus of claim 47, wherein the second oscillator is a ring oscillator, a relaxation oscillator, or a phase shift oscillator.

49. The apparatus of claim 1, further comprising:

a mode selector coupled to the frequency controller, the mode selector adapted to periodically start and stop the resonator to provide a pulsed output signal.

50. The apparatus of claim 1, further comprising:

a mode selector coupled to the frequency controller, the mode selector adapted to selectively start and stop the resonator to provide a power conservation mode.

51. An apparatus, comprising:

a resonator adapted to provide a first signal having a resonant frequency;

an amplifier coupled to the resonator;

a temperature compensator coupled to the amplifier and to the resonator, the temperature compensator adapted to modify the resonant frequency in response to temperature;

a process variation compensator coupled to the resonator, the process variation compensator adapted to modify the resonant frequency in response to fabrication process variation;

a frequency divider coupled to the resonator, the frequency divider adapted to divide the first signal having the resonant frequency into a plurality of second signals having a corresponding plurality of frequencies, the plurality of frequencies substantially equal to or lower than the resonant frequency; and

a frequency selector coupled to the frequency divider, the frequency selector adapted to provide an output signal from the plurality of second signals.

52. The apparatus of claim 51, wherein the first signal is a differential, substantially sinusoidal signal and the frequency divider is further adapted to convert the differential, substantially sinusoidal signal to a single-ended, substantially square wave signal having a substantially equal high and low duty cycle.

53. The apparatus of claim 51, wherein the first signal is a differential, substantially sinusoidal signal and the frequency divider is further adapted to convert the differential, substantially sinusoidal signal to a differential, substantially square wave signal having a substantially equal high and low duty cycle.

54. The apparatus of claim 51, wherein the frequency selector comprises a multiplexer and a glitch-suppressor.

55. The apparatus of claim 51, further comprising:

a mode selector coupled to the frequency selector, the mode selector adapted to provide a plurality of operating modes, the plurality of operating modes selected from a group comprising a clock mode, a timing and frequency reference mode, a power conservation mode, and a pulse mode.

56. The apparatus of claim 51, further comprising:

a controlled oscillator adapted to provide a third signal

a synchronization circuit coupled to the mode selector and to the controlled oscillator, the synchronization circuit adapted to modify the third signal in response to the output signal.

57. The apparatus of claim 51, wherein the amplifier further comprises a negative transconductance amplifier and wherein the temperature compensator is further adapted to modify a current through the negative transconductance amplifier in response to temperature.

58. The apparatus of claim 51, wherein the temperature compensator is further adapted to modify a capacitance of the resonator in response to temperature.

59. The apparatus of claim 51, further comprising:

a voltage isolator coupled to the resonator and to the temperature compensator, the voltage isolator adapted to substantially isolate the resonator from a voltage variation.

60. The apparatus of claim 51, wherein the temperature compensator further comprises:

a coefficient register adapted to store a first plurality of coefficients and a second plurality of coefficients;

a first array having a plurality of binary-weighted switchable capacitance branches coupled to the coefficient register and to the resonator, each switchable capacitance branch having a fixed capacitance and a variable capacitance and responsive to a corresponding coefficient of the first plurality of coefficients to switch between the fixed capacitance and the variable capacitance and to switch the variable capacitance to a control voltage node;

a second array coupled to the control voltage node, the second array having a plurality of switchable resistances coupled to the coefficient register and further having a fixed capacitance, each switchable resistive module responsive to a corresponding coefficient of the second plurality of coefficients to switch the switchable resistive module to the control voltage node;

a temperature-dependent current source coupled through a current mirror to the second array.

61. The apparatus of claim 51, wherein the process variation compensator further comprises:

a coefficient register adapted to store a plurality of coefficients;

an array having a plurality of binary-weighted, switchable capacitive modules coupled to the coefficient register and to the resonator, each switchable capacitive module having a first fixed capacitance and a second fixed capacitance, each switchable capacitive module responsive to a corresponding coefficient of the plurality of coefficients to switch between the first fixed capacitance and the second fixed capacitance; and

a frequency calibration module adapted to generate the plurality of coefficients in response to a reference signal.

62. The apparatus of claim 51, wherein the process variation compensator further comprises:

a coefficient register adapted to store a plurality of coefficients;

an array having a plurality of binary-weighted, switchable variable capacitive modules coupled to the coefficient register and to the resonator, each switchable variable capacitive module responsive to a corresponding coefficient of the plurality of coefficients to switch between a first voltage and a second voltage; and

a frequency calibration module adapted to generate the plurality of coefficients in response to a reference signal.

63. The apparatus of claim 51, wherein the resonator is selected from a group comprising: an inductor (L) and a capacitor (C) coupled to form an LC-tank resonator, a ceramic resonator, a mechanical resonator, a microelectromechanical resonator, and a film bulk acoustic resonator.

64. The apparatus of claim 51, further comprising:

a second oscillator providing a second oscillator output signal; and

a mode selector coupled to the frequency selector and to the second oscillator, the mode selector adapted to switch to the second oscillator output signal to provide a power conservation mode.

65. The apparatus of claim 1, further comprising:

a mode selector coupled to the frequency controller, the mode selector adapted selectively start and stop the resonator to provide a power conservation mode or a pulsed output signal.

66. A method of generating a reference signal, the method comprising:

generating a resonant signal having a resonant frequency;

adjusting the resonant frequency in response to temperature;

adjusting the resonant frequency in response to fabrication process variation;

divide the resonant signal having the resonant frequency into a plurality of second signals having a corresponding plurality of frequencies, the plurality of frequencies substantially equal to or lower than the resonant frequency; and

selecting an output signal from the plurality of second signals.

67. The method of claim 66, wherein the resonant signal is a differential, substantially sinusoidal signal, and wherein the method further comprises:

converting the differential, substantially sinusoidal signal to a single-ended, substantially square wave signal having a substantially equal high and low duty cycle.

68. The method of claim 66, further comprising:

selecting an operating mode from a plurality of operating modes, the plurality of operating modes selected from a group comprising a clock mode, a timing and frequency reference mode, a power conservation mode, and a pulse mode.

69. The method of claim 66, further comprising:

synchronizing a third signal in response to the output signal.

70. An apparatus for generating a clock signal, the apparatus comprising:

an LC resonator adapted to provide a differential, substantially sinusoidal first signal having a resonant frequency;

a negative transconductance amplifier coupled to the LC resonator;

a temperature compensator coupled to the negative transconductance amplifier and to the LC resonator, the temperature compensator adapted to modify a current in the negative transconductance amplifier in response to temperature and further to modify a capacitance of the LC resonator in response to temperature;

a process variation compensator coupled to the LC resonator, the process variation compensator adapted to modify the capacitance of the LC resonator in response to fabrication process variation;

a frequency divider coupled to the resonator, the frequency divider adapted to convert and divide the first signal having the resonant frequency into a plurality of differential or single-ended, substantially square-wave second signals having a corresponding plurality of frequencies, the plurality of frequencies substantially equal to or lower than the resonant frequency, and each second signal having a substantially equal high and low duty cycle; and

a frequency selector coupled to the frequency divider, the frequency selector adapted to provide an output signal from the plurality of second signals.